PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification: B01D 46/52, 25/04, 27/06, 29/16, 29/26	A1	(11) International Publication Number: WO 79/00978 (43) International Publication Date: 29 November 1979 (29.11.79)

(21) International Application Number: PCT/US79/00257

(22) International Filing Date: 23 April 1979 (23.04.79)

(31) Priority Application Number: 898,906

(32) Priority Date: 24 April 1978 (24.04.78)

(33) Priority Country: US

(71) Applicant: DONALDSON COMPANY, INC. [US/US]; 1400 West 94th Street, Minneapolis, MN 55431, (US).

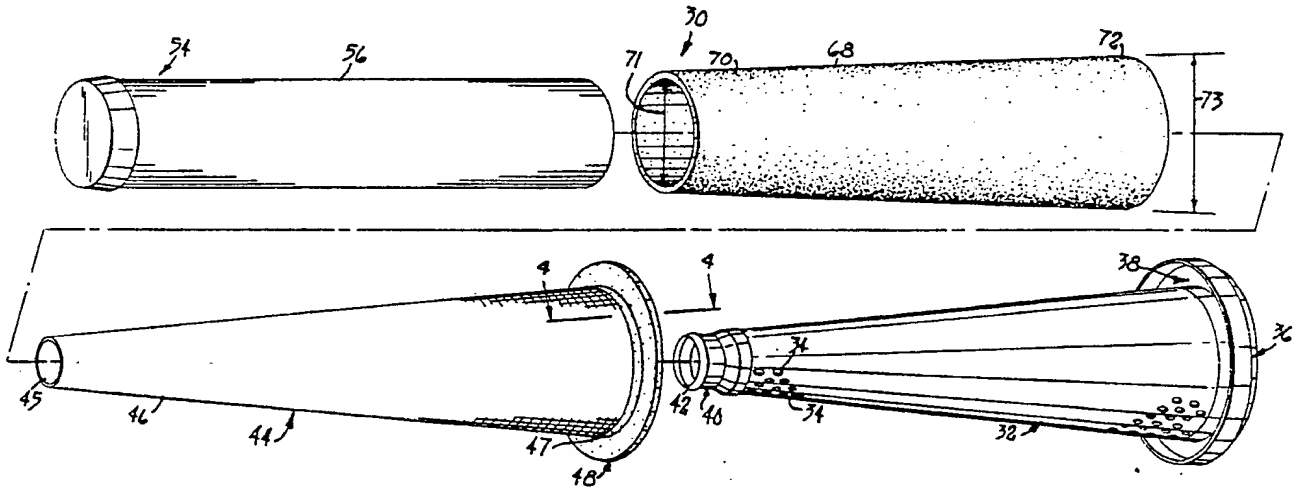
(72) Inventors: TOKAR, Joseph, C.; 6205-137th Street West, Apple Valley, MN 55124, (US). JANEZICH, Frank, A.; 7445 Lyndale Avenue South Richfield, MN 55423, (US).

(74) Agents: MILLER, James, W.; Suite One Thousand, Northwestern National Bank Building, Saint Paul, MN 55101, (US) et al.

(81) Designated States: BR, CH, DE, GB, JP, LU, SE, SU.

Published with:
International search report

(54) Title: AIR CLEANER WITH REPLACEABLE FILTER ELEMENT



(57) Abstract

An improved filter element assembly (30) for use in an air cleaner (2) on an internal combustion engine comprises a perforated inner liner (32). A replaceable filter element (54) comprising a pleated filter medium (56) is releasably coupled to the inner liner (32). A safety sleeve assembly (44) is interposed between the filter medium (56) and the inner liner (32). An outer liner (68) surrounds the filter medium (56) and exerts a radially inward force thereon to bias the pleats into engagement with the inner liner (32). The filter element assembly (30) can be reconditioned when the filter medium (56) becomes used with a replacement kit (90) which includes a new filter element (54), safety sleeve assembly (44), and outer liner (68). The used filter element assembly (30) is disassembled and the worn components thereof replaced with the new components of the kit (90). The filter medium (56) is expandable from a collapsed cylindrical form, in which the filter element (54) is shipped, to an expanded conical form for use during filtering operations.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT

AT	Austria	LU	Luxembourg
BR	Brazil	MC	Monaco
CF	Central African Empire	MG	Madagascar
CG	Congo	MW	Malawi
CH	Switzerland	NL	Netherlands
CM	Cameroon	RO	Romania
DE	Germany, Federal Republic of	SE	Sweden
DK	Denmark	SN	Senegal
FR	France	SU	Soviet Union
GA	Gabon	TD	Chad
GB	United Kingdom	TG	Togo
JP	Japan	US	United States of America

AIR CLEANER WITH REPLACEABLE FILTER ELEMENT

Technical Field

This invention relates in general to devices for removing dust and other particulate contaminants from air or similar gases. More particularly, this invention relates to an air cleaner having a replaceable filter element assembly for use on internal combustion engines.

Background of Prior Art

The internal combustion engine is a widely used power source which operates according to well-known principles. This type of engine is often used to power various movable vehicles, such as automobiles, trucks, snowmobiles, etc. In order for such an engine to operate properly, it is necessary to remove most of the dust, pollutants, or other particulate matter which is suspended in the air that is used as the intake air in the combustion process. Such particulate removal increases the efficiency at which the engine operates and prolongs the life of various engine components. Various types of air cleaners are used on internal combustion engines to filter the intake air.

More paritcularly, a special type of air cleaner is often used on the internal combustion engine of an over-the-road truck or the like. This air cleaner comprises a replaceable filter element assembly which is releasably contained inside a filter body. The filter element assembly includes two perforated spaced metal liners between which a pleated filter medium is contained. Two metal end caps integrally join the two liners and filter medium together to form a unitary filter element assembly. Whenever the pleated filter medium becomes too clogged for continued use in the filter body, it is necessary to replace the filter element assembly. This has been done in the past simply by discarding the entire filter element assembly,

including the metal liners and end caps, and replacing it with an unused assembly.

The prior art structure of the filter element assembly and the prior practice of discarding the entire filter element assembly when the filter medium becomes plugged is wasteful. This is apparent since at least some of the components of the filter element assembly (e.g., the two metal liners) could be reused. Because they are not reused however, the cost of each of the filter element assemblies is increased by the need to provide two new metal liners in each one. This increases the maintenance costs for the vehicle on which such air cleaners are used. In addition, the air cleaners in commercial trucks are often replaced according to a schedule depending on the number of miles driven by the truck rather than the actual condition of the filter medium. This often means that such air cleaners are replaced before it is strictly necessary (i.e., when the filter medium has become plugged with filtered particles). Thus, the maintenance costs for vehicles using these air cleaners are further increased by the type of maintenance prevalent in the industry.

In addition, the previous filter element assemblies have been shipped from the factory in an assembled form with the filter medium being placed in the expanded form in which the medium is normally operable. Since the filter medium is often conically shaped, the fully assembled filter element assembly is usually quite large. As such these assemblies take up a great deal of space. This increases both the shipping costs and also the inventory cost of storing such filter element assemblies. In addition, because each new filter element assembly also includes two new metal liners, the weight of each assembly is also increased. This further causes an increase in shipping costs.

SUMMARY OF THE INVENTION

One aspect of this invention is to provide an improved filter element assembly for use in an air cleaner such that any permanent or non-replaceable portions of the filter element assembly are reused.

This invention comprises a filter element assembly which is to be rejuvenated or reconditioned as necessary whenever the filter medium therein becomes plugged beyond effective use. The filter element assembly of this invention comprises an inner metal liner having a U-shaped housing or end cup at one end and an annular locking rib at the other end. A safety sleeve assembly comprising a porous filter is to be slipped over the inner metal liner to substantially cover the entire length of the liner. The safety sleeve assembly has a gasket at one end which is received inside the end cup of the liner. A replaceable filter element is adapted to be releasably coupled to the metal liner. The filter element comprises a pleated filter medium having an end cap integrally fixed to one end. The end cap has a locking groove which receives the locking rib on the liner in a snap fit to lock the filter element, the safety sleeve assembly and the liner together. The other end of the pleated filter medium is generally received inside the end cap adjacent the gasket on the safety sleeve assembly. In addition, a conical outer liner is received around the pleated filter medium. The outer liner has a diameter at one end which is less than the diameter of the corresponding end of the pleated filter medium. This ensures that inward pressure will be exerted by the outer liner on the pleats of the filter medium to force the pleats into engagement with the inner liner and to space the pleats evenly around the periphery of the medium.

The pleated filter element, safety sleeve assembly, and the outer liner are meant to be sold in a

replacement kit. The inner metal liner is to be retained and reused during subsequent air cleaning operations. The filter element is made in a collapsible form. Thus, the filter medium can take a substantially cylindrical form for shipping and have a substantially conical form when attached to the liner for use during the air filtering process. This decreases the shipping size of the replacement components of the filter element assembly to decrease the shipping costs of the filter element assembly of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will be described hereafter in the Detailed Description, when taken in conjunction with the following drawings, in which like references numerals will denote like elements throughout the several views.

Fig. 1 is a side elevational view, partly in cross-section taken along the lines 1-1 of Fig. 2, of an improved air cleaner according to this invention, showing the filter element assembly of this invention installed in a filter body;

Fig. 2 is a bottom plan view of the assembled air cleaner of Fig. 1;

Fig. 3 is an exploded perspective view of the components of the filter element assembly shown in Fig. 1;

Fig. 4 is a partial cross-sectional view of the end of the safety sleeve assembly, as taken along the lines 4-4 of Fig. 3;

Fig. 5 is a cross-sectional view of the structure of a first embodiment of the filter element assembly according to this invention, as taken along lines 5-5 of Fig. 1;

Fig. 6 is a cross-sectional view of the structure of a second embodiment of the filter element assembly according to this invention, taken along lines generally similar to those of 5-5 of Fig. 1;

Fig. 7 is a partial cross-sectional view of the bottom of the filter element assembly according to this invention as installed in a filter body in an air cleaner; and

Fig. 8 is a perspective view of a plurality of replacement kits for the filter element assemblies according to this invention, showing four such kits in a shipping container with one of the kits being opened to illustrate the components thereof.

DETAILED DESCRIPTION

Referring first to Fig. 1, an improved air cleaner according to this invention is generally indicated as 2. Air cleaner 2 is preferably meant for use with respect to an internal combustion engine (not shown) used as the power source for a movable vehicle. More particularly, air cleaner 2 as shown herein is of a type which is customarily used on over-the-road trucks and similar vehicles. However, the principles of this invention are not limited for use with regard to air cleaners on trucks or vehicles, but are generally applicable to any type of air cleaner or filtering device regardless of the type of equipment on which the air cleaner 2 is used. In addition, this invention is also applicable to all gaseous filtering devices whether the gas being filtered comprises air or some other gas.

Air cleaner 2 comprises a metallic filter body 4 which is substantially cylindrical having an elongated interior filter chamber 6 therein. Filter body 4 has an air intake conduit 8 and an air outlet conduit 10. Filter body 4 is releasably or fixedly attached to the truck body (not shown) in any suitable manner. Intake conduit 8 is placed in fluidic communication with a source of ambient air and outlet conduit 10 is suitably attached to the air intake ports of all the cylinders in the internal combustion

engine (not shown) with which air cleaner 2 is associated.

The end 11 of filter body 4 opposite to the end which carries outlet conduit 10 has an outwardly extending and annular mounting flange or retaining ring 12 which extends around the entire periphery of the filter body 4. End 11 of filter body 4 is normally open but is adapted to be closed by a detachable closure or cover 14. Cover 14 has an annular shoulder or lip 16 which is generally opposed to retaining ring 12. An annular gasket 18 is interposed between the lip 16 and ring 12. A plurality of bolts 20, which are releasably tightened by a plurality of threaded nuts 22, couple the ring 12 and 16 together in a releasable manner to effect attachment of cover 14. When the nuts 22 are tightened on bolts 20, gasket 18 will be compressed to effect an air-tight seal between the filter body 4 and the detachable cover 14. Cover 14 is detachable so that a filter element assembly, which is generally indicated as 30, can be removed and replaced from filter chamber 6. In this regard, it is preferred that cover 14 be easily accessible for replacement of filter element assembly 30 without having to detach filter body 4 from the truck body.

Referring to Figs. 1 and 3, an improved filter element assembly according to this invention is shown generally as 30. Filter element assembly 30 comprises four separate components. The first component comprises an elongated porous inner liner 32. Liner 32 includes a generally conically shaped hollow, metallic body having a plurality of perforations 34 evenly spaced over its entire length. One end of the liner 32 is provided with an integral U-shaped annular housing or cup 36. Cup 36 defines a chamber 38 which points or faces back along the axis of liner 32. The other end of liner 32 has a reduced diameter section or portion 40. Reduced diameter

portion 40 is provided with an outwardly protruding annular locking rib 42. The purpose of locking rib 42 and annular cup 36 will be explained in more detail hereafter. Since liner 32 is made of metallic materials, it is substantially permanent or reusable. Although it is preferred that liner 32 be metallic, the liner could also be made of any other suitably durable and permanent materials (e.g., high-impact plastic) which would allow liner 32 to be reused.

The second component of filter element assembly 30 comprises an elongated generally conically shaped safety sleeve assembly 44. Safety sleeve assembly 44 comprises a lightweight and flexible safety filter 46 which is made of any suitably porous cloth or fabric type material. One preferred material comprises a felt type fabric made from rayon and polyester. Safety filter 46 is relatively thin and very porous to air. The largest diameter end 47 of the safety filter 46 is fixedly coupled to a foamed urethane gasket 48. Referring to Fig. 4, gasket 48 comprises a radially extending flange 50 and an axially extending flange 52. Axially extending flange 52 has a slot in which the large diameter end 47 of the safety filter 46 is suitably secured as by gluing or the like.

Referring to Figs. 1 and 3, filter element assembly 30 further includes an elongated filter element 54. Filter element 54 comprises an expandable filter medium 56 having a plurality of longitudinal pleats 58 therein. Filter medium 56 can have the pleats 58 thereof collapsed until it takes on a generally cylindrical form (Fig. 3), or pleats 58 can be expanded until filter medium 56 has a generally conical shape substantially identical to the shape of liner 32 (Fig. 1). In the conical form, filter medium 56 has a small diameter end 59 and a large diameter end 60. Filter medium 56 has a hollow bore 61 running therethrough which is adapted to receive inner liner 32 in a manner to be described hereafter.

An end cap 62 of molded polyurethane is integrally attached, as by gluing, to the small diameter end 59 of the filter medium 56. To facilitate this attachment, end cap 62 is attached when the pleats 58 have been collapsed such that filter medium 56 is in its smallest possible size. End cap 62 has a hollow cylindrical bore 64 which is shaped to receive the reduced diameter portion 40 of liner 32. Bore 64 of cap 62 is aligned with bore 61 of filter medium 56. An annular locking groove 66 is located in bore 64 and receives the locking rib 42 on liner 32 in a snap-fit arrangement as described hereafter. Although locking rib 42 and locking groove 66 define a preferred means for detachably locking filter medium 56 to liner 32, any other suitable releasable locking means could be used.

Filter medium 56 may comprise any material which is porous to air or the other gas to be filtered but which is non-porous to the particulate matter suspended in the air. Common materials for filter medium 56 are paper and similar types of material which may also be chemically treated to enhance the filtering properties of medium 56.

In addition, filter element assembly 30 comprises a hollow outer wrap or liner 68 which also has a generally conical form. One end 70 of outer liner 68 has a diameter 71 which is generally equal to the small diameter end 59 of the pleated filter medium 56. The other end 72 of outer liner 68 has a somewhat larger diameter 73 for a purpose to be described hereafter. Outer liner 68 is preferably made of a foamed urethane material. This material is open celled and thus quite porous to air and other gases, and is also resilient.

One preferred method of forming outer liner 68 is to form the urethane material into a flat sheet, roll the sheet into the required cone shape, and then secure the sides 74 and 76 of the sheet together. The sides 74 and 76 of liner 68 are secured together generally as shown in the two embodiments of Figs. 5 and 6. As shown in Fig. 5, the sides 74 and 76 of the outer liner

68 may each have a section 78 of reduced thickness. Sections 78 are overlapped and heat sealed together in a generally conventional manner. Alternatively, the sides 74 and 76 of outer liner 68 may also be simply abutted against one another as shown in Fig 6. These abutting sides 74 and 76 are then heat sealed together. Although heat sealing is preferred in attaching the sides 74 and 76 together, any other suitable attachment means could be used.

Having described the various components of filter element assembly 30, the method of assembling and using filter element assembly 30 is unique when compared to that of prior art assemblies. More particularly, referring to Fig. 3, each filter element assembly 30 is assembled from the basic components shown therein. A preferred method of assembling these components is as follows. Safety sleeve assembly 44 is first slipped over the exterior surface of the inner liner 32 with the safety filter 46 covering the entire length of the liner 32 and the gasket 48 having its annular flange 50 received inside the chamber 38 of end cup 36. Safety filter 46 is long enough to cover the entire length of liner 32 and may have its free end 45 (i.e., the end opposite to gasket 48) formed in either an open or closed manner. Fig. 1 illustrates an open configuration for end 45 while Fig. 3 illustrates a closed configuration. In any event, the end 45 of the safety filter is generally tucked into the inside of the inner liner 32 as shown in Figs. 1 and 3.

After placing the safety filter 46 onto the inner metal liner 32, the operator then places the outer liner 68 around the pleated filter medium 54 when medium 56 is still in a collapsed form. More particularly, the outer liner 68 is placed around filter medium 56 with the smallest diameter end 70 thereof being received generally around the smallest diameter end 59 of medium 56 and abutting against the end cap 62. Because the other end 72 of the outer liner 68 has a diameter 73 which is larger than the collapsed diameter of the other end 60 of the

pleated medium 56, there will be some space provided between the outer liner 68 and filter medium 56 at this end. This ensures that liner 68 can be quickly and easily slipped around filter medium 56.

After outer liner 68 is placed around filter medium 56, the inner metal liner 32 with the attached safety sleeve assembly 44 is pushed down inwardly through the bore 61 of the pleated filter medium 56. Because of the tapered conical shape of the inner metal liner 32, as liner 32 is moved downwardly through the filter medium 56, the pleats 58 will be expanded until filter medium 56 assumes its conical form corresponding to the shape of liner 32. Inner liner 32 is moved downwardly through the pleated filter medium 56 until locking rib 42 engages the interior annular locking groove 66 on the end cap 62 in a snap fit. When this occurs, the upper large diameter end 60 of the pleated filter medium 56 will be fully expanded and will be received inside the chamber 38 of end cup 36 generally adjacent the sealing flange 50 of gasket 48. Gasket flange 50 seals the upper end 60 of filter medium 56 in a substantially air tight manner relative to end cup 36. This prevents air leaks around end 60 if any of the adjacent portions of pleats 58 should become damaged. In addition, the outer liner 62 will also have its upper end abutting against the end of the end cup 36 as shown in Fig. 1 at 79.

When the pleated filter medium 56 is fully expanded, its large diameter end 59 will have an outer diameter of approximately 8.5 inches. However, the largest diameter 73 of the outer large diameter end 72 of liner 68 is smaller (e.g., 7 inches). Thus, the outer liner 68 will be placed in tension which results in a radially inward force on each of the pleats 58. This radially inward force causes the pleats 58 to firmly engage the inner liner 32. In addition, the inward force tends to ensure that all the pleats 58 will be evenly spaced around the periphery of the pleated filter medium 56, and also serves to dampen any movement of the pleats 58 which

might occur through vibration or fluctuations in the air pressure on pleats 58.

When all the components of filter element assembly 30 have been assembled in the above-noted manner, this assembly 30 can then be easily installed into filter chamber 6 of filter body 4. In this regard, detachable cover 14 is removed by uncoupling the nuts 22 from the bolts 20 and by lifting cover 14 off filter body 4. With the end cover 14 removed, the largest diameter end of the filter element assembly 30 is first inserted into filter chamber 6. Cover 14 is then replaced and recoupled to the filter body 4. When the nuts 22 are tightened, the cover 14 will engage the end cap 62 on the pleated filter medium 56 to force the entire assembly 30 upwardly into filter chamber 6. The exterior surface of the cup 36 on the metal liner 32 has an annular outwardly extending sealing gasket 80 which engages the end wall of the filter body 4 when cover 14 is replaced to form an air-tight seal therewith. Thus, air will flow into air cleaner 2 through the air intake conduit 8, through the porous outer liner 68, the filter medium 56, the safety sleeve assembly 44, the perforated inner metal liner 32, and then finally outwardly through the air outlet conduit 10. Outlet conduit 10 is aligned with the bore 61 of filter medium 56 and the interior of liner 32 as shown in Fig. 1. During the passage of air in the above-noted manner, all or substantially all of the particular matter contained in the air will be absorbed by the filter medium 56, at least for particulate matter above a certain minimum predetermined size.

The air cleaner 2 which incorporates the improved filter element assembly 30 according to this invention has a number of advantages. A complete air cleaner 2 will usually be sold and installed on an existing truck or other movable vehicle with the filter body 4 being generally fixedly mounted on the vehicle. This initial purchase of air cleaner 2 will include a completed and assembled filter element assembly 30 located in filter

chamber 6. As the vehicle on which air cleaner 2 is installed is driven, filter element assembly 30 filters the combustion air entering the internal combustion engine of the truck.

After the vehicle is operated a sufficient time such that the filter medium 56 becomes plugged and no longer is capable of properly filtering additional air, then the filter element assembly 30 is rejuvenated or reconditioned by removing the detachable cover 14 and disassembling the components 32, 44, 54 and 68 of the assembly. In this regard, the user of the air cleaner 2 will then purchase or have purchased a replacement kit, generally indicated as 90, of the replaceable or so-called "soft" components of the filter element assembly 30. Replacement kit 90 will include all of the components of the original filter element assembly 30 except for the inner metal liner 32 which can be reused. Thus, replacement kit 90 includes a new filter element 54, a new safety sleeve assembly 44, and a new outer liner 68, packaged generally as shown in Fig. 8 in a shipping container 92. After having disassembled the components of the used filter element assembly 30, the used soft components 44, 54 and 68 thereof can then be discarded and replaced with the corresponding components of the filter element assembly replacement kit 90. Generally, the method of reassembling the filter element assembly 30 with the new soft components of replacement kit 90 will be identical to the assembling procedure described above. In other words, the safety sleeve assembly 44 is first positioned over the reusable metal liner 32, the outer liner 68 is then positioned over the pleated filter medium 56, and, finally, the inner metal liner 32 with the attached safety sleeve assembly 44 is pushed down through bore 61 of filter medium 56 until the end cap 62 locks with the locking rib 42 on liner 32.

Filter element assembly 30 according to this invention is substantially less expensive (i.e., up to 50% less expensive) that prior art assemblies in which

all the components thereof, including the metal liners, are discarded and replaced when the filter medium becomes plugged. This decrease in cost occurs because metal liner 32 is reused for successive cycles of filtering operations, thereby eliminating one of the more expensive components in prior filter element assemblies. Because filter element assembly 30 is less expensive, the costs of operating and maintaining any vehicles using such filter element assemblies can be reduced. This is especially true since the structure of filter element assembly 30 allows easy inspection of filter medium 56. For example, the assembly 30 can be easily disassembled and the filter medium 56 checked for wear before assembly 30 is reconditioned with replacement kit 90. Such reconditioning can thereof be done only when filter medium 56 is fully plugged and beyond continued effective use. This eliminates the waste of the prïor practice of discarding and replacing filter element assemblies according to a mileage schedule rather than the actual condition of the filter medium.

In addition, the particular type of filter element 54 used in assembly 30 has a number of advantages. Because the pleated filter medium 55 can assume a substantially cylindrical form for shipping, but yet can be expanded into a conical form during use in the air cleaner 2, the size of the shipping containers 92 for the replacement kits 90 can be greatly decreased. Generally, four replacement kits 90 can now be shipped in a single shipping carton 94 of the size which would have been suitable for shipping only a single prior art filter element assembly in which the filter medium could not be collapsed. Obviously, a great savings in both the shipping and storage costs of replacement kits 90 can now be effected with the filter element 54 of this invention. In addition, because each replacement kit 90 need no longer have a metal liner 32 therein, this kit is thus lighter which also contributes to a decrease in shipping costs. This decrease further increases the advantages

and utility of the filter element assembly 30 of this invention.

Although it is preferred that filter medium 56 be expandable, this is not strictly necessary to the other aspects of this invention (i.e., the concept of using a permanent metal liner 52 and reconditioning the assembly 30 with the soft components 44, 54, and 68.) Instead, the pleated filter medium 56 could be provided only having a conical form. However, this configuration would increase the size, and thus the shipping costs of the replacement kits 90.

An added advantage of the improved filter element assembly of the present invention is that the outer liner 68, which is preferably made from an open celled material such as foamed urethane, acts as a precleaner. The outer wrap or liner 68 filters some unwanted material, primarily the larger particles from the air flowing through the assembly, thereby extending the life of the pleated filter element.

Various other modifications of this invention may be apparent to those skilled in the art. Thus, the scope of this invention is to be limited only by the appended claims.

WHAT IS CLAIMED IS:

1. An improved filter element assembly for use in an air cleaning device having a filter body which defines a filter chamber, said filter element assembly being releasably contained in said filter body, wherein said filter element assembly comprises:

(a) an elongated perforated liner assembly said liner assembly being made from a material which is substantially permanent during operation of the air cleaning device, whereby said liner assembly can be reused during successive air cleaning operations;

(b) a filter element which includes a filter medium having a plurality of pleats, said filter medium being made from a material which is substantially porous to air and substantially non-porous to predetermined particulate matter suspended in the air, whereby said filter medium removes the particulate matter from the air;

(c) locking means for releasably coupling said filter element to said liner assembly, whereby said filter element may be detached from said liner assembly when said filter medium becomes plugged with the particulate matter to allow said liner assembly to be reused; and

(d) an outer liner surrounding and engaging said filter medium, wherein said outer liner has a configuration when engaging said filter medium which exerts a radially inward force on said pleats.

2. An improved filter element assembly as recited in claim 1, wherein said liner assembly comprises a metal liner having an annular locking rib at one end thereof, and wherein said filter element includes an end cap to which one end of said filter medium is fixedly attached, said end cap having a locking groove which receives said locking rib on said liner in a snap fit to

releasably couple said filter element to said liner.

3. An improved filter element assembly as recited in claim 1, further including a safety sleeve assembly positioned between said liner assembly and said filter element.

4. An improved filter element assembly as recited in claim 3, wherein said liner assembly comprises a metal liner having an annular cup at one end which defines an annular chamber, said chamber receiving one end of said filter medium when said filter element is coupled to said liner, and wherein said safety sleeve assembly comprises a flexible porous safety filter which covers said liner, said safety filter having an annular gasket at one end thereof, said gasket being placed in said chamber against said one end of said filter medium to prevent leakage of air therearound.

5. An improved filter element assembly as recited in claim 1, wherein said filter medium has an interior bore therein, and wherein said liner assembly comprises an inner metallic liner which extends through said bore when said filter element is coupled to said liner to lie in the interior of said filter medium.

6. An improved filter element assembly as recited in claim 1, in which both said liner assembly and said filter medium have a conical shape when said filter element is coupled to said liner assembly, said filter medium being collapsible and expandable between a conical configuration and a cylindrical configuration whereby said filter element may be shipped with said filter medium in its said cylindrical configuration.

7. An improved filter element assembly as recited in claim 1, in which the filter medium is made of paper.

8. An improved filter element assembly for use in an air cleaning device having a filter body, wherein said filter element assembly comprises:

(a) an elongated and perforated liner having a locking rib at one end thereof and an annular

cup at the other end thereof;

(b) a filter element releasably coupled to said liner, said filter element have an interior bore and comprising a filter medium having opposed first and second ends, said first end of said filter medium being received in said end cup on said liner and said second end of said filter medium having an end cap attached thereto, said end cap having an annular locking groove which receives said locking rib when said liner is inserted into the bore of said filter element;

(c) a safety sleeve assembly which comprises a porous safety filter having a gasket attached to one end, said safety filter being positioned between said filter element and said liner with said gasket being received between said first end of said filter medium and said end cup to seal said first end therein;

(d) wherein said annular locking rib is configured relative to said annular locking groove to form a snap fit, whereby said filter element, said liner, and said safety sleeve assembly may be releasably interlocked into a completed filter element assembly; and

(e) an outer liner which surrounds and engages said filter medium, said filter medium having a plurality of longitudinal pleats, said outer liner being configured to apply radially inward pressure on said pleated filter medium to hold said pleats thereof against said liner in an evenly spaced manner.

9. An improved filter element assembly as recited in claim 8, in which both said outer liner, said pleated filter medium and said liner are conically shaped when coupled together, said outer liner having approximately the same diameter as that of said pleated filter medium at said second end thereof, said outer liner having a

smaller diameter than that of said pleated filter medium at said first end thereof, whereby said outer liner is placed under tension at said first end of said filter medium to apply said inward pressure.

10. An improved filter element assembly as recited in claim 8, wherein said liner is made of a metallic material such that said liner can be reused during subsequent air cleaning operations.

11. An improved filter element assembly as recited in claim 8, in which the filter medium is made of paper.

12. A replacement kit for an improved filter element assembly, said replacement kit having component parts capable of being assembled in the field for association with a conically shaped perforated liner for providing a reconditioned filter element assembly, said assembly being received in a filter body of an air cleaning device, said replacement kit comprising the combination of;

(a) a filter element, said filter element having a pleated filter medium which is integrally attached at one end to an end cap, said end cap having means for releasably locking said filter element to one end of said liner, said filter medium and said end cap having an interior bore which receives said liner therein;

(b) a safety sleeve assembly which comprises a porous safety filter having a gasket at one end, said safety filter being suitable for being positioned between said filter element and said liner when said filter element is releasably coupled to said liner, said gasket being received between one end of said pleated filter medium and said end cup on said liner to seal said one end of said filter medium relative to said end cup; and

(c) a resilient outer liner which is to be received around said pleated filter medium, said outer liner being configured to apply

inward pressure on said pleats of said filter medium to force said pleats into contact with said liner.

13. A replacement kit as recited in claim 12, in which the filter medium is collapsible and expandable between a conical configuration and a cylindrical configuration, whereby said filter element may be shipped with said filter medium in its said cylindrical configuration and said filter medium may assume a conical configuration when said filter element is coupled to said liner.

14. A replacement kit as recited in claim 12, wherein said outer liner has a smaller diameter at one end than the diameter of said pleated filter medium at a corresponding end thereof, whereby said outer liner is placed under tension at said one end to apply inward pressure on said pleats.

15. A replacement kit as recited in claim 12, in which the filter medium is made of a material which is substantially porous to air and non-porous to predetermined particulate matter suspended in the air.

16. An improved filter element assembly for use in an air cleaning device, which comprises:

(a) an inner liner having a locking rib at one end thereof;

(b) a filter element which comprises:

(i) an elongated hollow filter medium comprising a plurality of pleats which extend longitudinally along an axis of said filter medium, said pleats enabling said filter medium to be expanded and contracted between a first and second configuration, said filter medium further being made of a material which is substantially porous to air and non-porous to predetermined particulate matter suspended in the air; and

(ii) an end cap fixedly attached to one

end of said filter medium, said end cap having an interior bore provided with a locking groove for receiving said locking rib on said liner to couple said filter element to said liner, said filter element when assembled to said liner having said pleats thereof expanded into said second configuration to substantially simulate an exterior configuration of said liner; and

(c) an outer liner which encircles and engages the filter element to apply a radially inward force on said pleats.

17. An air cleaning device for removing predetermined particulate matter suspended from air, which comprises:

(a) a filter body having an air intake and an air outlet, said filter body having an open end for providing access to an interior filter chamber;

(b) a detachable cover for closing said open end in said filter body, said cover being removable from said filter body to give access to said filter chamber;

(c) a filter element assembly contained in said filter chamber whereby air passes through said air intake, through said filter element assembly and out through said air outlet with the particulate matter in said air being absorbed by said filter element assembly, said filter element assembly comprising:

(i) an elongated perforated liner assembly said liner assembly being made from a material which is substantially permanent during operation of the air cleaning device, whereby said liner assembly can be reused during successive air cleaning operations;

(ii) a filter element which includes a filter medium having a plurality of pleats, said filter medium being made from a material which is substantially porous to air and substantially non-porous to predetermined particulate matter suspended in the air, whereby said filter medium removes the particulate matter from the air;

(iii) locking means for releasably coupling said filter element to said liner assembly, whereby said filter element may be detached from said liner assembly when said filter medium becomes plugged with the particulate matter to allow said liner assembly to be reused; and

(iv) an outer liner surrounding and engaging said filter medium, wherein said outer liner has a configuration when engaging said filter medium which exerts a radially inward force on said pleats.

FIG. 2

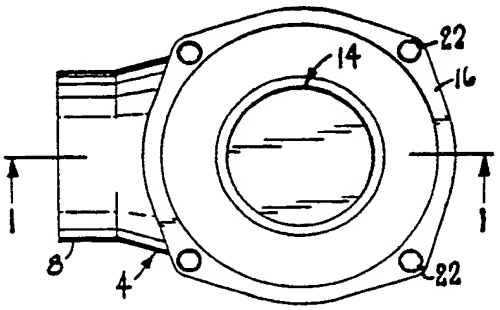
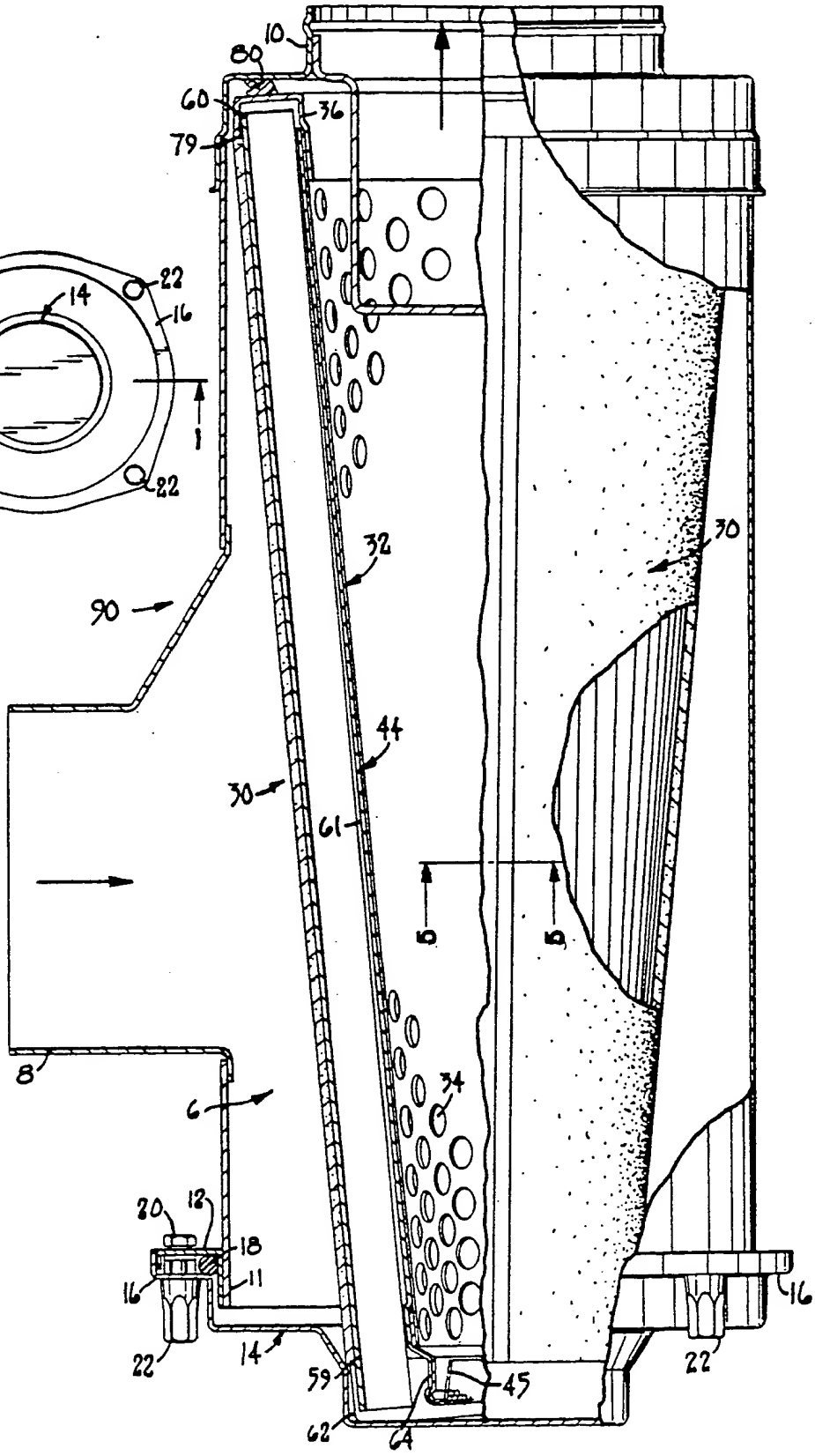


FIG. 1



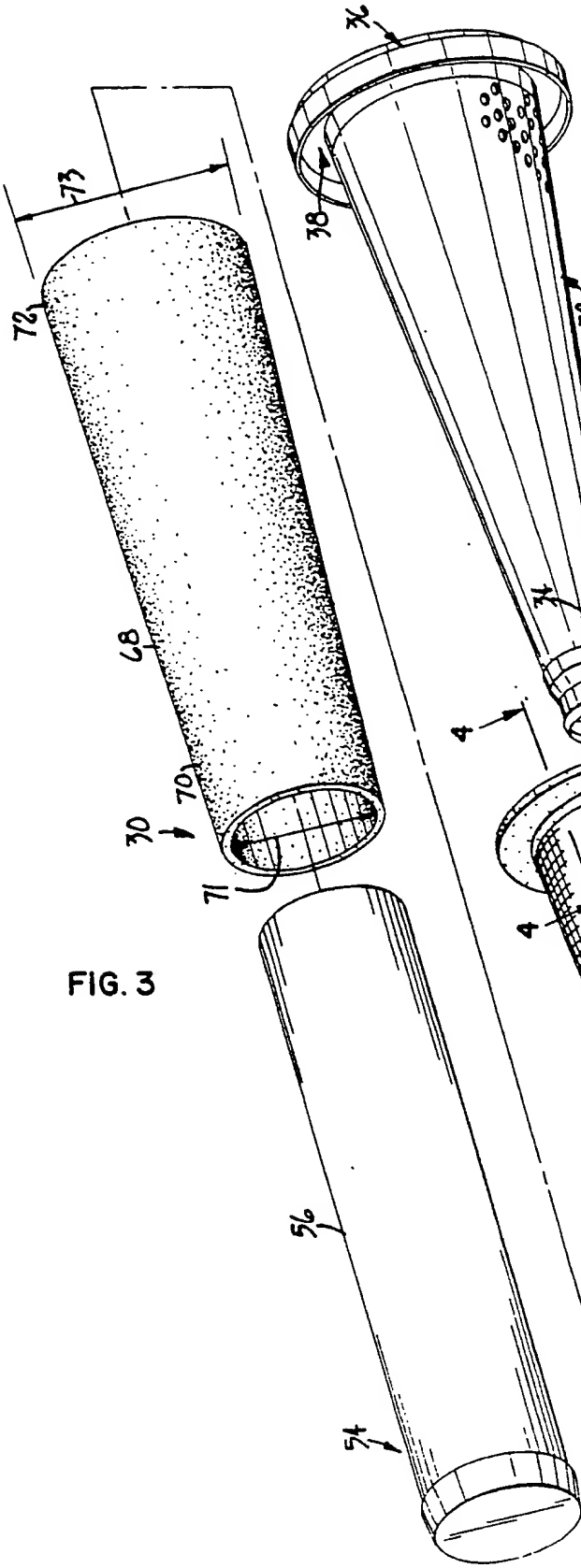


FIG. 3

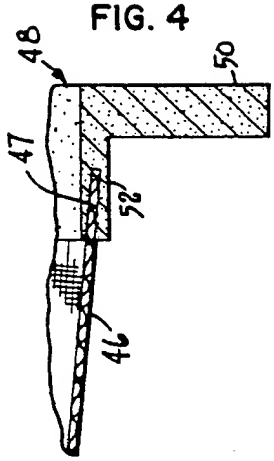


FIG. 4

FIG. 5

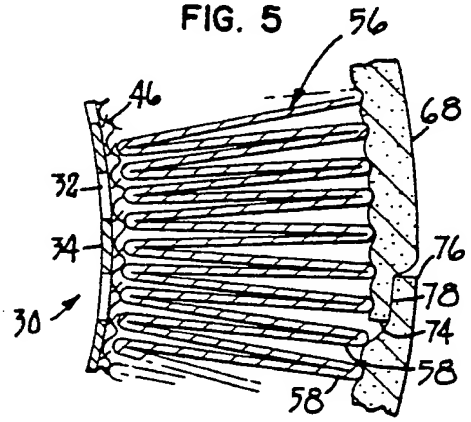


FIG. 6

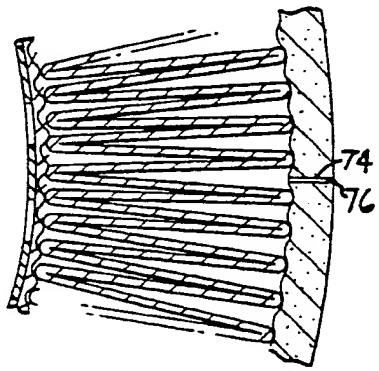


FIG. 7

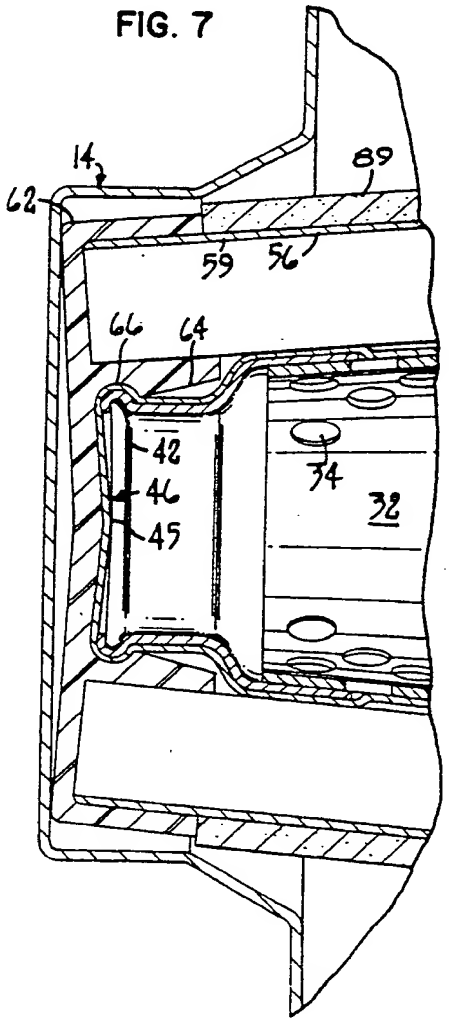
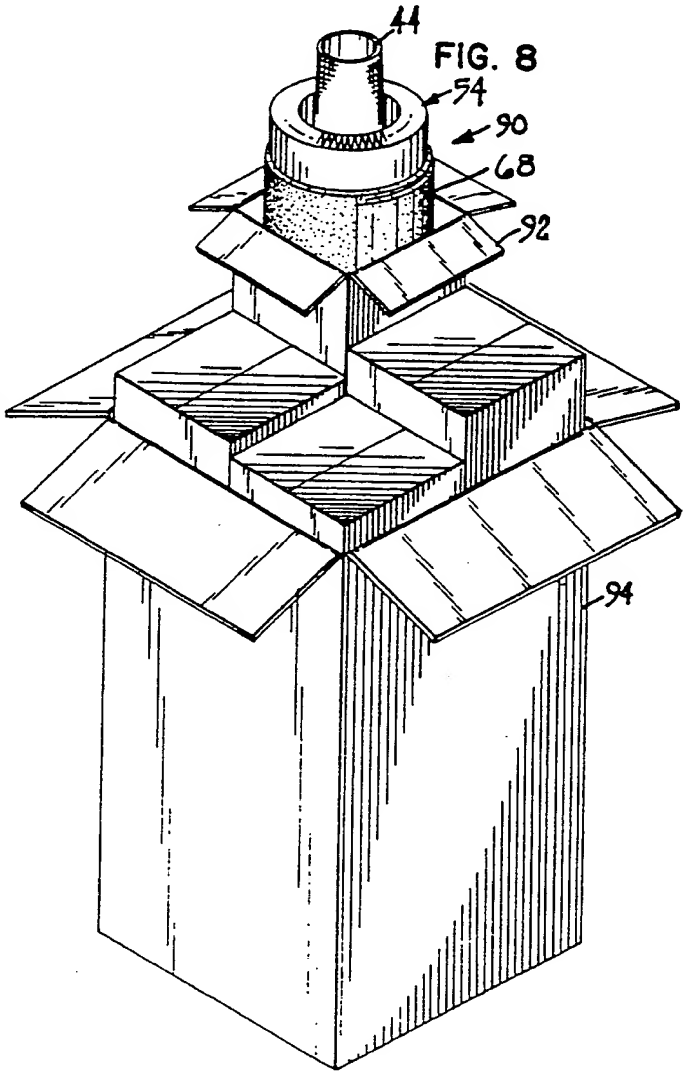


FIG. 8



INTERNATIONAL SEARCH REPORT

International Application No PCT/US79/00257

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL. B01D 46/52, 25/04, 27/06, 29/16, 29/26 B01D/00298

U.S. CL. 55/482,497,502,503,509,521;210/489,493R,497R

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	55/485-489,492,497-500,502,503,509,521; 210/457,461,484,485,487,493R,497R

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X,P	US,A, 4,135,899, PUBLISHED 23 JANUARY 1979, GAUER.	1-17
X	US,A, 3,498,464, PUBLISHED 03 MARCH 1970, FROSOLONE.	1-3,5,6, 12-17
X	US,A, 4,006,000, PUBLISHED 01 FEBRUARY 1977, TORTORICI ET AL.	6,17
X	GB,A, 880,469, PUBLISHED 25 OCTOBER 1961.	17
A	US,A, 2,550,070, PUBLISHED 24 APRIL 1951, LA BRECQUE ET AL.	1-10
A	US,A, 2,537,992, PUBLISHED 16 JANUARY 1951, GROSS ET AL.	1-7
X	US,A, 3,458,050, PUBLISHED 29 JULY 1969, COOPER.	1-7

* Special categories of cited documents: [15]

"A" document defining the general state of the art

"E" earlier document but published on or after the international filing date

"L" document cited for special reason other than those referred to in the other categories

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
15 JUNE 1979	9 JUL 1979
International Searching Authority [1]	Signature of Authorized Officer [20]
ISA/US	David L. Lacey

Form PCT/ISA/210 (second sheet) (October 1977)